The Response of Growth and Production of Red Rice of the Bahbutong and Aek Sibundong Varieties to Gamma-Ray Irradiations

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Abstract. The purpose of this study was to identify the effect of gamma-ray irradiation on the growth and production of red rice Aek sibundong and Bahbutong varieties. This research was carried out on the farmer's land Jl Sedar, Batang Kuis, Deli Serdang Regency, North Sumatra, Medan. This study used a randomized block design (RBD) with two treatment factors. The first factor is the variety consisting of V1 = Bahbutong, V2 = Aek Sibundong. The second factor is the irradiation dose which consists of 4 levels namely, R0 = 0 Gy, R1 = 100 Gy, R2 = 200 Gy, R4 = 300 Gy. The results showed that the best dose of gamma-ray irradiation in reducing plant height, accelerating the age of flowering and increasing production was 200 Gy. Aek Sibundong variety red rice showed better growth and production response than Bahbutong variety.

Keywords: *Oryza sativa* L, variety, gamma rays, growth, production

1 Introduction

Rice (*Oryza sativa* L) is a major carbohydrate food crop in the world. Brown rice in particular is a potential food ingredient for food diversification programs. This is because the nutritional content of brown rice is higher than white rice. In addition to the main source of carbohydrates, brown rice also contains protein, beta-carotene, antioxidants and iron [1].

Along with increasing the standard of living of the people and awareness of the importance of health, some people need quality rice that is beneficial for health. However, so far, red rice is still rarely cultivated by farmers in Indonesia because of its long life (an average of 134 days) and its plant morphology is high (an average of 164 cm) making it easy to fall over [2]. Whereas economically, superior rice with short maturity and short posture are more profitable so that farmers are cultivated more than rice with a deep age. Classification of rice harvesting age according to IBPGR (1980) standards is early 110-125 days, moderate 126-145 days, and within> 145 days.

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One way that can be done to improve the genetics of brown rice is by breeding mutations using gamma-ray irradiation. Mutation breeding can create genetic diversity that is very useful for improving just a few traits by not changing most of the traits of the original plants that have been favored. Because not much has changed the breeding of mutations requires a relatively shorter time in the purification process of the strain [3].

Mutation induction using irradiation produces the most mutants (around 75%) when compared to other treatments such as chemical mutagens. Gamma rays are short, high-energy electromagnetic waves that interact with atoms or molecules to produce free radicals in cells. Free radicals will induce mutations in plants because these radicals will produce cell damage or important influences in plant cell components [4].

Research results of Farisa [5] on local varieties of rice, that the radiation dose affects the plants, seen from the data specifications of mutant plants is very different from the control plants, especially in the data on the number of productive tillers, the number of rice grains, the weight of 100 grains and the age of harvest. Data on mutant plants showed higher yields than control plants, at the age of harvest the harvest age showed 26 days faster than the control plants. Furthermore Mugiono *et al* [6] in the improvement of rice varieties of Cisantana with induction mutations, an increase in productivity of rice varieties of Cisanta which experienced irradiation doses of 100 Gy, 200 Gy and 300 Gy compared with controls, and after conducting research up to M3 and M4 and also in the rainy season and dry season, the productivity of mutant rice is higher compared to control rice.

Until 2005, rice varieties produced in Indonesia reached 180 varieties. Of all these varieties, there is only one red rice variety, namely Bahbutong. However, this variety is less developed and not widely cultivated by farmers [7]. After that, in 2006 the Agricultural Research and Development Agency produced Aek Sibundong red rice varieties that are lowland rice. Just like Bahbutong, this variety is less developed.

In its natural habitat, accessions of local brown rice are now increasingly rare. Almost all farmers grow new varieties of rice including hybrid rice, only a small proportion of them cultivate local red rice. As a result, the existence of local brown rice is increasingly rare, even endangered [8]. Therefore, research is needed on local varieties of red rice Bahbutong and Aek Sibundong using gamma-ray radiation that aims to obtain mutant plants with the desired characteristics.

2 Research Method

The materials used in this study were local varieties of red rice seeds Bahbutong and Aek Sibundong. This research was carried out on the farmer's land Jl Sedar, Batang Kuis Deli Serdang Regency, North Sumatra, Medan in May-September 2019. The study used a Randomized Block Design (RBD) with two treatment factors. The first factor is the variety consisting of V1 = Bahbutong, V2 = Aek Sibundong. The second factor is the irradiation dose which consists of 4 levels namely, R0 = 0 Gy, R1 = 100 Gy, R2 = 200 Gy, R4 = 300 Gy.

Rice seeds are packaged in plastic and labeled according to the treatment of 200 grams. The packed seed is put into a Chamber 4000A CO^{60} gamma-ray irradiator for some time to obtain the required dose.

Fertilization and maintenance of plants are carried out by recommendations for rice cultivation. The parameters observed were plant height (cm), age of flowering (days) and weight of 1000 grains (g).

3 Results and Discussion

3.1 Plant Height (cm)

Table 1 below presents the average plant height of the two red rice varieties to several doses of gamma-ray irradiation at each observation.

Table 1. The average plant height of two varieties of red rice to several doses of gamma-ray irradiation at each observation

DAP	Varieties (V)	Doses of Irradiation				Mean
		0 Gy (R_0)	100 Gy (R_1)	200 Gy (R_2)	300 Gy (R_3)	
		……cm…….……..				
20	Bahbutong (V_1)	53.33 a	52.00 a	49.78 ab	51.73 a	51.71 a
	Aek Sibundong (V_2)	46.60 ab	47.78 ab	44.67 b	47.67 ab	46.68 b
	Mean	49.97 a	49.89 a	47.23 ab	49.70 a	
40	Bahbutong (V_1)	76.80 a	75.20 a	76.08 a	79.07 a	76.79 a
	Aek Sibundong (V_2)	69.67 b	69.77 b	68.53 b	67.80 b	68.94 b
	Mean	73.23 a	72.48 a	72.31 ab	73.43 a	
60	Bahbutong (V_1)	78.60 a	78.25 a	77.50 a	80.28 a	78.66 a
	Aek Sibundong (V_2)	70.93 b	71.63 b	71.55 b	69.88b	71.00 b
	Mean	74.77 a	74.94 a	74.53 ab	75.08 a	

Note: Those numbers followed by the same alphabet on the same application unreally different by Duncan test Average Difference α=5%

Based on the average plant height in **Table 1**, it can be seen that the lowest plant height was found in the treatment R2 (200 Gy) which is 74.53 cm while the highest plant height was found in treatment R3 (300 Gy). This shows that plant height increases with an increasing dose of gamma-ray irradiation, but the increase is not much different from control plants. This is by Warman et al [9], which states that when M1 is planted in the field there is a visible pattern of normal plant growth and no significant differences are found between the irradiation dose with each other, even with the control plants (without irradiation).

3.2 Flowering Age

Table 2 below presents the average flowering age of two varieties of red rice to several doses of gamma-ray irradiation.

Table 2. The average flowering age of two red rice varieties to several doses of gamma-ray irradiation

Varieties (V)	Doses of Irradiation				Mean
	0 Gy (R_0)	100 Gy (R_1)	200 Gy (R_2)	300 (R_3)	
	……..…days.……..……				
Bahbutong (V_1)	82.00 c	88.83 a	83.67 c	87.00 ab	85.38 a
Aek Sibundong (V_2)	82.00 c	78.00 d	77.00 d	85.00 bc	80.50 b
Mean	82.00 b	83.42 b	80.33 c	86.00 a	

Note: Those numbers followed by the same alphabet on the same application unreally different by Duncan test Average Difference α=5%

Based on the average flowering age in **Table 2**, it can be seen that the fastest flowering age is in the treatment of 200 Gy (R2) gamma-ray irradiation doses. This shows that mutations in plants can cause changes in plant parts both in shape and color as well as changes in other properties including flowering age. According to Yunita [10], genetic changes resulting from gamma-ray radiation occur because of the increase or loss of one or more bases contained in a DNA molecule. The variety factor also affects the flowering age of rice plants, where the flowering age of Aek Sibundong varieties is faster than Bahbutong varieties. This is due to the genetic differences of each variety. According to Sitompul and Guritno [11], very large differences in varieties affect plant properties, because different genetic factors can be expressed in a variety of plant traits that include the shape and function of plants that will ultimately produce a variety of plant growth.

3.3 Weight of 1000 grains (gr)

Table 3 below percentage average weighted of 1000 grains of two red rice varieties to several doses of gamma-ray irradiation.

Table 3. The average weight of 1000 grains of two red rice varieties to several doses of gamma-ray irradiation

Varieties (V)	Doses of Irradiation				Mean
	0 Gy (R_0)	100 Gy (R_1)	200 Gy (R_2)	300 (R_3)	
	……grams.……..……..				
Bahbutong (V_1)	26.33 abc	25.25 c	27.20 a	26.74 ab	26.38 a
Aek Sibundong (V_2)	25.70 bc	26.86 ab	27.09 a	26.52 ab	26.54 a
Mean	26.01 c	26.05 c	27.14 a	26.63 b	

Note: Those numbers followed by the same alphabet on the same application unreally different by Duncan test Average Difference α=5%

Based on the average weight of 1000 grains in **Table 3**, it can be seen that the highest weight of 1000 items is not found at the highest dose, but at a dose of 200 Gy gamma-ray irradiation,

which is 27.14 grams. This shows that lower doses can produce better character than the control plants. Nurjanah [12] states that the use of lower doses of radiation exposure has been able to cause a large genetic effect. Often, lower doses can give mutants better results than higher radiation doses. Giving higher doses often cause physical damage that affects the weight of the seeds.

In addition to the irradiation dose factor given, other factors that affect plant growth and yield are the environments, such as humidity, rainfall, temperature, sunlight and temperature. These factors can affect rice production, especially when filling seeds. Lu [13], temperature greatly affects the filling of seeds, which with optimal temperature and humidity at the time of flowering, is very good for the fertilization process.

4 Conclusion

Gamma-ray irradiation affects plant height, flowering age and plant seed weight. Gamma-ray irradiation at a dose of 200 Gy can reduce plant height, accelerate flowering age and increase the weight of 1000 grains on Aek Sibundong variety rice.

5 References

[1] Kristamtini dan H. Purwaningsih. Potensi pengembangan beras merah sebagai plasma nutfah Yogyakarta. *J. Litbang Pertanian 28(3):88-89*. (2009).

[2] Silitonga, T.S. *Katalog SDG tanaman pangan tahun 2015*. Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumberdaya Genetik Pertanian. Bogor. (2015).

[3] Sianipar., J., L.A.P. Putri., S. Ilyas. Pengaruh radiasi sinar gamma terhadap tanaman kacang hijau (*Virginia radiata* L.) pada kondisi kekeringan. *J. Agrotek, 1 (2), 136-14*. (2013).

[4] Kovacs, E, dan A. Keresztes. *Effect of gamma and UV-B/C radiation on plant cell*. Micron, 33:199-210. (2002).

[5] Farisa, D. *Pengujian Potensi Radiasi Sinar Gamma Terhadap Mutan Padi (Oryza sativa L.) Varietas Lokal Mentik Susu dan Umbul*. Surakarta. (2015).

[6] Mugiono, L. Harsanti. dan A.K. Dewi. Perbaikan Padi Varietas Cisanta Dengan Mutasi Induksi. *J. Ilmiah Aplikasi Isotop dan Radiasi 5(2):65-75.* (2009).

[7] Suardi, K.D. Potensi beras merah untuk peningkatan mutu pangan. *J. Litbang Pert. 24(3): 93–100.* (2005).

[8] Kristamtini. *Menyelamatkan sumber daya genetik padi berah merah*. Warta Plasma Nutfah Indonesia 21: 4–6. (2009).

[9] Warman, B., Sobrizal., I. Suliansyah., E. Swasti., A. Syarif. Perbaikan Genetik Kultivar Padi Beras Hitam Lokal Sumatera Barat Melalui Mutasi Induksi. *A Scientific Journal for The Applications of Isotopes and Radiation Vol. 11 No. 2.* (2015).

[10] Yunita, Rossa. Pemanfaatan Variasi Somaklonal dan Seleksi In Vitro dalam Perakitan Tanaman Toleran Cekaman Abiotik. *Jurnal Litbang Pertanian. 28(4): 142-148.* (2009).

[11] Sitompul, S. M., dan B. Guritno, *Analisis Pertumbuhan Tanaman*. Gadjah Mada University Press. Yogyakarta. (1995).

[12] Nurjanah, E. *Pengaruh Kombinasi NaCl dan ZPT IBA pada Media MS terhadap Pertumbuhan Galur Mutan Padi Secara Invitro. Skripsi*. Program Studi Biologi. Fakultas Sains dan Teknologi. Universitas Islam Negeri Syarif Hidayatullah. (2009).

[13] Lu, B.R. *Taxonomy of the genus Oryza (Poaceae): historical perspective and current status*. Mini review, IRRI. 24 (3): 4-8. (1999).